

Search Interfaces for Biomedical Searching: How do Gaze, User Perception, Search Behaviour and Search Performance Relate?

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Research Questions

- What elements of search interfaces do searchers look at when searching for documents to answer complex questions?
- What is the relationship between **individual differences** and the **interface elements** which are looked at?

Medical Subject Headings

Medical Subject Headings (MeSH) – is a controlled and hierarchically-organized vocabulary produced by **the National Library of Medicine**:



- It is used for indexing, cataloging, and searching of biomedical and health-related information
- MeSH is more useful for experts ... but they still need help
- Automatic query expansion is still variable



PubMed Advanced Search Example¹



t-cell lymphoma autoimmune symptoms



Search

Search	Actions	Details	Query	Results	Time
#2	...	▼	<p>Search: t-cell lymphoma autoimmune symptoms</p> <p>["lymphoma, t cell"[MeSH Terms] OR ("lymphoma"[All Fields] AND "t cell"[All Fields]) OR "t-cell lymphoma"[All Fields] OR "t cell lymphoma"[All Fields]) AND ("autoimmune"[All Fields] OR autoimmunity"[MeSH Terms]) OR "autoimmunity"[All Fields] OR "autoimmunities"[All Fields] OR "autoimmunization"[All Fields] OR "autoimmunizing"[All Fields] AND ("diagnosis"[MeSH Subheading] OR "diagnosis"[All Fields] OR "symptoms"[All Fields] OR diagnosis"[MeSH Terms] OR "symptom"[All Fields] OR "symptom s"[All Fields] OR "symptomes"[All Fields])</p> <p>Translations</p> <p>t-cell lymphoma: "lymphoma, t-cell"[MeSH Terms] OR ("lymphoma"[All Fields] AND "t-cell"[All Fields]) OR "t-cell lymphoma"[All Fields] OR "t cell lymphoma"[All Fields]</p> <p>autoimmune: "autoimmune"[All Fields] OR autoimmunity"[MeSH Terms] OR "autoimmunity"[All Fields] OR "autoimmunities"[All Fields] OR "autoimmunization"[All Fields] OR "autoimmunizing"[All Fields]</p> <p>symptoms: "diagnosis"[Subheading] OR "diagnosis"[All Fields] OR "symptoms"[All Fields] OR diagnosis"[MeSH Terms] OR "symptom"[All Fields] OR "symptom's"[All Fields] OR "symptomes"[All Fields]</p>	585	01:31:50

¹ <https://pubmed.ncbi.nlm.nih.gov/advanced/>

Four type of interfaces

acute tubular necrosis dye contrasts

Your search for acute tubular necrosis dye contrasts returned 1 results.

Bubble cells: renal tubular cells in the urinary sediment with characteristics of viability.

Graber M, Lane B, Larisa R, Pasteriza-Munoz E. *J Am Soc Nephrol* 1(7):999-1004

The urinary sediment was examined by light microscopy in 65 consecutive inpatients with renal insufficiency (not due to pre- or postrenal factors) referred to a nephrology consult service for evaluation. In the 60 patients in whom a single diagnosis was reached, the sediments of 34 (57%) contained an easily recognized cell, which we have called the "bubble cell". These cells were bizarre, large cells . . .

(a) Standard SERP; No MeSH terms

Intravesical prostaglandin F2 for promoting bladder emptying after surgery for female stress incontinence.

Tamminen T, Koivumäki M, Kaar K, Lukkarinen O. *Br J Urol* 60(1):43-6.

Try: Female, Human, Adult, Aged, Middle Age, Male, Electromyography, Adolescence, Urodynamics, Urinary Tract/IR.

Prostaglandin F2 alpha 10 mg was administered intravesically in a double-blind placebo-controlled study to promote micturition after operative treatment of urinary stress incontinence in women. Fifteen of 18 patients (83%) succeeded with treatment with prostaglandin F2 alpha, but the placebo was ineffective in all 18 patients (P less than 0.001). Although the t

Suggested Keywords

(c) MeSH per-query; displayed per-doc

urinary retention after menopause

Your search for urinary retention after menopause returned 1 results.

Epidemiology of symptomatic infections of the urinary tract in children.

Uusari M, Naarala M. *BMJ* 7(2):460-461-465-2.

Try: Aging, Calcitonin/TU, Human, Bone Resorption/DE, Biological Markers, Menopause/PH, Osteoporosis/DI/ME/PP, Hydroxyproline/AN, Prolin/AN, Female.

Suggested Keywords

(b) MeSH per-query; displayed per-query

Epidemiology of symptomatic infections of the urinary tract in children.

Uusari M, Naarala M. *BMJ* 7(2):460-461-465-2.

Try: Adolescence, Age Factors, Child, Child, Preschool, Female, Finland, Hospitalization, Human, Infant, Infant, Newborn, Male, Recurrence, Risk Factors, Sex Factors, Support, Non-U.S. Gov't, Time Factors, Urinary Tract Infections/EP.

The epidemiology of symptomatic infections of the urinary tract in children and the factors that may alter the risk of infection are not known. Numbers of children aged under 15 discharged from hospitals because of symptomatic infections of the urinary tract during 1970-79 were obtained from the database kept by the Finnish National Board of Health. Information on continuous treatment for recurrent uri

Suggested Keywords

(d) MeSH per-doc; displayed per-doc

Search Topics and Collection

Tasks for searching: 8 topics selected from OHSUMED^[1] (clinical topics, rewritten)

Imagine that you are 63-year-old male with acute renal failure probably 2nd to aminoglycosides/contrast dye. You would like to find information about acute tubular necrosis due to aminoglycosides, contrast dye, outcome and treatment.

Collection: OHSUMED [test] + MEDLINE data 1987 to 1991

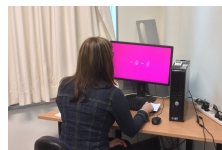
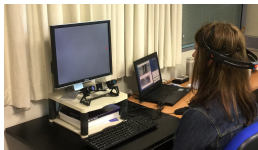
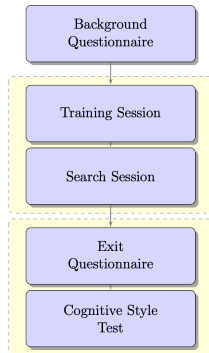
- 348,566 records

Users were informed the data is incomplete and out-of-date

[1] William Hersh et al. "OHSUMED: An Interactive Retrieval Evaluation and New Large Test Collection for Research". In: *Proceedings of the ACM SIGIR Conference (SIGIR '94)*. Vol. 17. Berlin, Heidelberg: Springer-Verlag, 1994, pp. 192–201. DOI: 10.1007/978-1-4471-2099-5_20.

Experimental Procedure

- $4 \times 4 \times 2$ factorial design (4 interfaces, 4 search topic pairs, 2 cognitive styles)
- Graeco–Latin square design for experimental conditions
- A total of 256 search sessions (32 participants, 8 search topics for each participant)
- Collecting: User characteristics, user perceptions, search behavior, gaze data



Search Performance Evaluation

For the *best query in session* (*bq*):

Retrieval Evaluation with Incomplete Information:

$$bpref_{bq} = \frac{1}{R} \sum_r \left(1 - \frac{|rel_n \text{ higher than } rel_r|}{\min(R, N)} \right)$$

R-Precision with r relevant docs count at R :

$$Rprec_{bq} = \frac{r}{R}$$

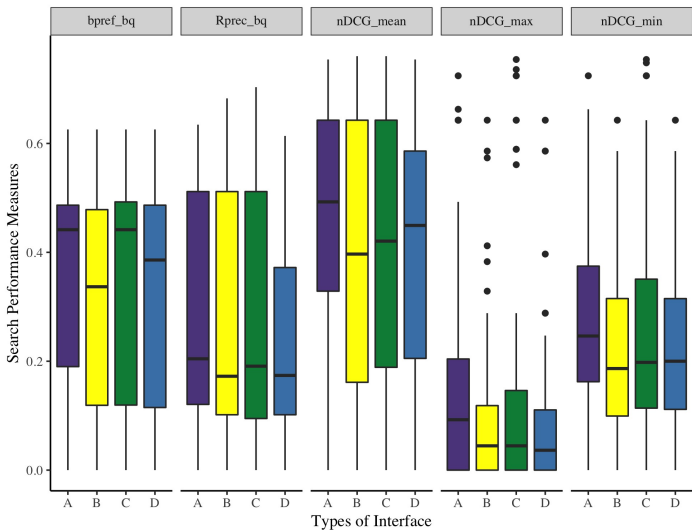
For a whole search session:

Discounted Cumulative Gain for k results:

$$DCG = \sum_{pos=1}^k \frac{rel_{pos}}{\ln(pos + 1)}$$

Result ranking (*rel*) – based on the vector space model, TF-IDF weighting.

Search Interfaces Results Comparison



Gaze \longleftrightarrow Search Performance

	<i>CutPoint</i> (Mean)	<i>Odds</i> <i>Ratio</i>	<i>Log</i> <i>Odds</i>	<i>Stand.</i> <i>Error</i>	<i>t-</i> <i>Value</i>	<i>Stat.</i> <i>Signif.</i>	<i>r</i> ES
Title						No	
Author						No	
Abstract							
<i>bpref_{bq}</i>	0.34	1.74	0.56	0.26	2.15	Yes	0.15
MeSH							
nDCG _{min}	0.12	0.54	-0.61	0.29	-2.12	Yes	-0.17
sDCG/q	1.72	0.58	-0.54	0.27	-2.02	Yes	-0.15

- Attention to the element of abstract are 1.74 (Odds Ratio) higher given the search performance by *bpref_{bq}*
- r-ES – correlation effect size

Task Difficulty and System Usefulness

	<i>CutPoint</i> (Mean)	<i>Odds</i> <i>Ratio</i>	<i>Log</i> <i>Odds</i>	<i>Stand.</i> <i>Error</i>	<i>t</i> - <i>Value</i>	<i>Stat.</i> <i>Signif.</i>	<i>r</i> ES
Search task difficulty \longleftrightarrow Search Performance							
<i>bpref_{bq}</i>	0.34	2.28	0.82	0.29	2.80	Yes	0.20
<i>Rprec_{bq}</i>	0.26	1.65	0.50	0.31	1.63	No	
nDCG_min	0.12	1.62	0.48	0.35	1.39	No	
nDCG_mean	0.25	1.77	0.57	0.30	1.90	No	
nDCG_max	0.43	1.77	0.57	0.29	1.95	No	
sDCG/q	1.72	1.24	0.21	0.31	0.70	No	
System usefulness \longleftrightarrow Search Performance						No	

When the search tasks were perceived difficult, they were 128% (2.28-1) more likely to obtain better search results in terms of *bpref_{bq}*

Keyword Notice \longleftrightarrow Search Performance (Interface B)

	<i>CutPoint</i> (Mean)	<i>Odds</i> <i>Ratio</i>	<i>Log</i> <i>Odds</i>	<i>Stand.</i> <i>Error</i>	<i>t</i> - <i>Value</i>	<i>Stat.</i> <i>Signif.</i>	<i>r</i> <i>ES</i>
<i>bpref</i> _{<i>bq</i>}	0.34	1.31	0.27	0.27	1.02	No	
<i>Rprec</i> _{<i>bq</i>}	1.26	1.12	0.11	0.27	0.41	No	
nDCG_max	0.43	1.24	0.21	0.26	0.81	No	
nDCG_min	0.12	0.29	-1.23	0.29	-4.19	Yes	-0.31
nDCG_mean	0.25	0.56	-0.58	0.26	-2.19	Yes	-0.15
sDCG/q	1.72	0.37	-0.99	0.27	-3.62	Yes	-0.26

Suggested Keywords

Your search for *urinary retention after menopause* returned 1 results.

Try: Aging; Calcitonin/*TU; Human; Bone Resorption/*DE; Biological Markers; Menopause/*PH; Osteoporosis/DT/ME/*PP; Hydroxyproline/AN; Proline/AN.; Female;

Keyword Notice \longleftrightarrow Search Performance (Interface D)

	<i>CutPoint</i> (Mean)	<i>Odds</i> <i>Ratio</i>	<i>Log</i> <i>Odds</i>	<i>Stand.</i> <i>Error</i>	<i>t</i> – <i>Value</i>	<i>Stat.</i> <i>Signif.</i>	<i>r</i> <i>ES</i>
<i>bpref_{bq}</i>	0.34	1.72	0.54	0.26	2.10	Yes	0.15
<i>Rprec_{bq}</i>	0.26	1.32	0.28	0.26	1.08	No	
nDCG_max	0.43	1.46	0.38	0.25	1.48	No	
nDCG_min	0.12	1.02	0.02	0.28	0.07	No	
nDCG_mean	0.25	1.06	0.06	0.25	0.25	No	
sDCG/q	1.72	0.68	-0.39	0.26	-1.46	No	

*Epidemiology of symptomatic infections of the urinary tract in children.*Uhari M, Nuutinen M. *BMJ* 297(6646):450-2

Try: Adolescence, Age Factors, Child, Child, Preschool, Female, Finland, Hospitalization, Human, Infant, Infant, Newborn, Male, Recurrence, Risk Factors, Sex Factors, Support, Non-U.S. Gov't, Time Factors, Urinary Tract Infections/*EP.

The epidemiology of symptomatic infections of the urinary tract in children and the factors that may alter the risk of infection are not known. Numbers of children aged under 15 discharged from hospitals because of symptomatic infections of the urinary tract during 1980-1990 were obtained from the database kept by the Finnish National Board of Health. Information on continuous treatment for recurrent urinary tract infections was obtained from the database kept by the Finnish National Board of Health.



Suggested Keywords

Keyword Notice \longleftrightarrow Search Performance (Interface C)

	<i>CutPoint</i> (Mean)	<i>Odds</i> <i>Ratio</i>	<i>Log</i> <i>Odds</i>	<i>Stand.</i> <i>Error</i>	<i>t-</i> <i>Value</i>	<i>Stat.</i> <i>Signif.</i>	<i>r</i> <i>ES</i>
$bpref_{bq}$	0.34	1.78	0.58	0.26	2.25	Yes	0.16
$Rprec_{bq}$	0.26	1.52	0.42	0.26	1.61	No	
nDCG_max	0.43	1.66	0.51	0.25	2.01	Yes	0.14
nDCG_min	0.12	0.50	-0.69	0.29	-2.40	Yes	-0.19
nDCG_mean	0.25	0.75	-0.28	0.25	-1.11	No	
sDCG/q	1.72	0.51	-0.68	0.27	-2.54	Yes	-0.19

Intravesical prostaglandin F2 for promoting bladder emptying after surgery for female stress incontinence.

Tammela T, Kontturi M, Kaar K, Lukkarinen O. *Br J Urol* 60(1):43-6

Try: Female, Human, Adult, Aged, Middle Age, Male, Electromyography, Adolescence, Urodynamics, Urinary Tract/IR;

Prostaglandin F2 alpha 10 mg was administered intravesically in a double-blind placebo-controlled study to promote micturition and reduce urinary retention after operative treatment of urinary stress incontinence in women. Fifteen of 18 patients (83%) succeeded with treatment with prostaglandin F2 alpha, but the placebo was ineffective in all 18 patients (P less than 0.001). Although the

Suggested Keywords

Use Keywords in Search \longleftrightarrow Search Performance

	<i>CutPoint</i> (Mean)	<i>Odds</i> <i>Ratio</i>	<i>Log</i> <i>Odds</i>	<i>Stand.</i> <i>Error</i>	<i>t</i> - <i>Value</i>	<i>Stat.</i> <i>Signif.</i>	<i>r</i> <i>ES</i>
Interface B						No	
Interface C							
<i>bpref_{bq}</i>	0.34	1.92	0.65	0.28	2.36	Yes	0.17
<i>Rprec_{bq}</i>	0.26	1.40	0.34	0.27	1.25	No	
nDCG_max	0.43	1.57	0.45	0.27	1.70	No	
nDCG_min	0.12	0.79	-0.23	0.30	-0.77	No	
nDCG_mean	0.25	0.91	-0.09	0.27	-0.35	No	
sDCG/q	1.72	0.65	-0.44	0.28	-1.54	No	
Interface D						No	

When users recognized and used the suggested keywords in C, (query per doc), they were 92% likely to obtain better search results.

Search Behavior \longleftrightarrow Search Performance

	<i>CutPoint</i> (Mean)	<i>Odds</i> <i>Ratio</i>	<i>Log</i> <i>Odds</i>	<i>Stand.</i> <i>Error</i>	<i>t</i> - <i>Value</i>	<i>Stat.</i> <i>Signif.</i>	<i>r</i> <i>ES</i>
Number of queries							
nDCG _{min}	0.12	0.11	-2.20	0.40	-5.57	Yes	-0.53
nDCG _{mean}	0.25	0.30	-1.20	0.27	-4.44	Yes	-0.31
sDCG/q	1.72	0.16	-1.80	0.32	-5.71	Yes	-0.45
Number of typed queries							
nDCG _{min}	0.12	0.27	-1.33	0.34	-3.93	Yes	-0.34
nDCG _{mean}	0.25	0.43	-0.83	0.27	-3.12	Yes	-0.22
sDCG/q	1.72	0.40	-0.93	0.29	-3.23	Yes	-0.25
Number of pages viewed							
nDCG _{min}	0.12	0.28	-1.27	0.35	-3.66	Yes	-0.33
nDCG _{mean}	0.25	0.47	-0.74	0.27	-2.75	Yes	-0.20
sDCG/q	1.72	0.34	-1.07	0.30	-3.57	Yes	-0.28

Summary of Findings

- Proposed search interfaces have significant effect on eye gaze behavior in terms of fixations
- MeSH terms:
 - Attracted to domain experts and analytic users [when displayed under a search box] (B – worse performance)

urinary retention after menopause Search

Your search for *urinary retention after menopause* returned 1 results.

Try: Aging; Calcitonin*TU; Human; Bone Resorption*DE; Biological Markers; Menopause*PH; Osteoporosis/DT/ME*PP; Hydroxyproline/AN; Proline/AN ; Female;

- Received more attention when displayed alongside each document for experienced searchers (C – mixed perf. , D – better perf.)

Intravesical prostaglandin F2 for promoting bladder emptying after surgery for female stress incontinence.

Tremblay T, Sorbati M, Kjaer K, Lohrborn D. *BJU Int* 2011;107:141-6

Try: Female; Human; Adult; Aged; Middle Age; Male; Electromyography; Adolescence; Urodynamics; Urinary Tract*IR;

Prostaglandin F2 alpha 10 mg was administered intravesically in a double-blind placebo-controlled study to promote micturition after operative treatment of urinary stress incontinence in women. Fifteen of 10 patients (15%) succeeded in treatment with prostaglandin F2 alpha, but the placebo was ineffective in all 10 patients (P less than 0.001). Although the

Suggested Keywords

Epidemiology of symptomatic infections of the urinary tract in children.

Ulan M, Naarala M. *BMJ* 2009;339:450-2

Try: Adolescence; Age Factors; Child; Child, Preschool; Female; Finland; Hospitalization; Human; Infant; Infant, Newborn; Male; Recurrence; Risk Factors; Sex Factors; Support; Non-U.S. Gov't; Time Factors; Urinary Tract Infections*EP;

The epidemiology of symptomatic infections of the urinary tract in children and the factors that may alter the risk of infection are not known. Numbers of children aged under 15 discharged from hospitals because of symptomatic infections of the urinary tract during were obtained from the database kept by the Finnish National Board of Health. Information on continuous treatment for recurrent uri

Suggested Keywords

Conclusion

- People did better:
 - on difficult tasks
 - when they read abstracts
- People did better and worse when they used MeSH terms;
- Seems to be an interaction with the way they're generated and with the way they're given context
- There might be lessons for other search domains, too

Thank you for attention!



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